CLAIMS

What is claimed is:

1. A catheter comprising:

a body having a proximal end and a distal end, said distal end having a distal tip;

a contact electrode at said distal tip;

an array of non-contact electrodes on said distal end of said body, said array having a proximal end and a distal end; and

at least one location sensor on said distal end of said body.

2. The catheter of claim 1 wherein said at least one location sensor is proximate to said catheter distal tip.

3. The catheter of claim 1 wherein said at least one location sensor comprises a first location sensor and a second location sensor.

4. The catheter of claim 3 wherein said first location sensor is proximate to said catheter distal tip and said second location sensor is proximate to said proximal end of said array of non-contact electrodes.

5. The catheter of claim 4 wherein at least one of said first location sensor and said second location sensor provides six degrees of location information.

6. The catheter of claim 5 wherein said first location sensor and said second location sensor each provide six degrees of location information.

7. The catheter of claim 3 wherein at least one of said first location sensor and said second location sensor is an electromagnetic location sensor.

8. The catheter of claim 1 wherein said distal tip contact electrode is a bipolar electrode.

9. The catheter of claim 1 wherein said electrode array comprises from about twelve to about thirty-two non-contact electrodes.

10. The catheter of claim 9 wherein said array comprises from about sixteen to about twenty-four electrodes.

11. The catheter of claim 3 wherein said distal tip contact electrode is a bipolar electrode.

12. A catheter comprising:

a body having a proximal end and a distal end, said distal end having a distal tip;

an array of non-contact electrodes on said distal end of said body, said array having a proximal end and a distal end; and

at least one location sensor proximate to said catheter distal tip.

13. The catheter of claim 12 wherein said at least one location sensor comprises a first location sensor and a second location sensor.

14. The catheter of claim 13 wherein said first location sensor is proximate to said catheter distal tip and said second location sensor is proximate to said proximal end of said non-contact electrode array.

15. The catheter of claim 13 wherein at least one of said first location sensor and said second location sensor is an electromagnetic location sensor.

16. A method for generating an electrical map of a chamber of a heart, said map depicting an electrical characteristic of the chamber as a function of chamber geometry, said method comprising the steps of:

a) providing a catheter comprising a body having a proximal end and a distal end, said distal end having a distal tip; a contact electrode at said distal tip; an array of non-contact electrodes on said distal end of said body, said array having a proximal end and a distal end; and at least one location sensor on said distal end of said body;

b) advancing said catheter into said chamber of said heart;

c) contacting the wall of said chamber of said heart with said contact electrode at a plurality of contact points;

d) acquiring electrical information and location information from each of said electrodes and said at least one location sensor, respectively, said acquisition taking place over at least one cardiac cycle while said contact electrode is in contact with each of said contact points; and

e) generating an electrical map of said heart chamber from said acquired location and electrical information.

17. The method of claim 16 wherein said at least one location sensor comprises a first location sensor and a second location sensor.

18. The method of claim 17 wherein said first location sensor is proximate to said distal tip of said catheter.

19. The method of claim 18 wherein said second location sensor is proximate to the proximal end of said array of non-contact electrodes.

20. The method of claim 19 wherein at least one of said first location sensor and said second location sensor provides six degrees of location information.

21. The method of claim 20 wherein said first location sensor and said second location sensor each provide six degrees of location information.

22. The method of claim 17 wherein at least one of said location sensors is an electromagnetic location sensor.

23. The method of claim 16 wherein said contact electrode is a bipolar electrode.

24. The method of claim 16 wherein said array of non-contact electrodes comprises from about twelve to about thirty-two non-contact electrodes.

25. The method of claim 24 wherein said array of non-contact electrodes comprises from about sixteen to about twenty-four non-contact electrodes.

26. The method of claim 17 including determining said geometry of said heart chamber from the location information provided by of each of said location sensors.

27. The method of claim 16 wherein said generating step (e) comprises computing the location of said contact electrode and each of said non-contact electrodes, said locations being the location of said contact electrode and said non-contact electrodes during acquisition of said electrical and location information.

28. The method of claim 27 wherein said chamber geometry is derived from the location of said contact electrode and each of said non-contact electrodes during acquisition step (d).

29. The method of claim 28 wherein said electrical map is derived from:

    i) the location of said contact electrode and of each of said non-contact electrodes during acquisition of said electrical and location information; and from

    ii) the electrical information acquired by the contact electrode at each of said contact points.

30. The method of claim 29 wherein said electrical characteristics intermediate said contact points are derived from the electrical information acquired from said non-contact electrodes.

31. The method of claim 27 wherein said electrical map is derived from:

i) the location of said contact electrode and of each of said non-contact electrodes during acquisition of said electrical and location information; and from

ii) the electrical information acquired by said contact electrode and each of said non-contact electrodes.

32. The method of claim 16, including ablating a portion of said heart chamber based on said electrical map.

33. The method of claim 32 which further comprises validating the effectiveness of the ablation procedure.

34. The method of claim 33 wherein said validation comprises acquiring additional electrical information from said catheter following said ablation procedure.

35. A method for generating an electrical map of a chamber of a heart, said map depicting an electrical characteristic of the chamber as a function of chamber geometry, said method comprising the steps of:

a) providing a catheter comprising a body having a proximal end and a distal end, said distal end having a distal tip; an array of non-contact electrodes on said distal end of said body, said array having a proximal end and a distal end; and at least one location sensor proximate to said catheter distal tip;

b) advancing said catheter into said chamber of said heart;

c) contacting the wall of said chamber of said heart with said catheter distal tip at a plurality of contact points;

d) acquiring electrical information and location information from each of said electrodes and location sensors, respectively, said acquisition taking place over at least one cardiac cycle while said catheter distal tip is in contact with each of said contact points; and

e) generating an electrical map of said heart chamber from said acquired location and electrical information.

36. The method of claim 35 wherein said at least one location sensor comprises a first location sensor and a second location sensor.

37. The method of claim 36 wherein said first location sensor is proximate to said catheter distal tip.

38. The method of claim 37 wherein said second location sensor is proximate to the proximal end of said electrode array.

39. The method of claim 35 including ablating a portion of said heart chamber based on said electrical map.

40. The method of claim 39 which further comprises validating the effectiveness of the ablation procedure.

41. The method of claim 40 wherein said validation comprises acquiring additional electrical information from said catheter following said ablation procedure.

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42. Apparatus for generating an electrical map of a chamber of a heart, said map depicting an electrical characteristic of the chamber as a function of chamber geometry, said apparatus comprising:

a catheter including a body having a proximal end and a distal end, said distal end having a distal tip; a contact electrode at said distal tip; an array of non-contact electrodes on said distal end of said body, said array having a proximal end and a distal end; and at least one location sensor on said distal end of said body; said catheter being adapted to contacting the wall of said chamber of said heart with said contact electrode at a plurality of contact points; and

a signal processor operatively connected to said catheter for acquiring electrical information and location information from each of said electrodes and location sensors, respectively, over at least one cardiac cycle while said contact electrode is in contact with each of said contact points, said signal processor also generating an electrical map of said heart chamber from said acquired location and electrical information.

43. The apparatus of claim 42 wherein said catheter comprises a first location sensor and a second location sensor.

44. The apparatus of claim 43 wherein at least one of said first location sensor and said second location sensor is an electromagnetic location sensor.

45. The apparatus of claim 43 wherein said first location sensor is proximate to said catheter distal tip.

46. The apparatus of claim 45 wherein said second location sensor is proximate to the proximal end of said electrode array.

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47. Apparatus for generating an electrical map of a chamber of a heart, said map depicting an electrical characteristic of the chamber as a function of chamber geometry, said apparatus comprising:

a catheter including a body having a proximal end and a distal end, said distal end having a distal tip; an array of non-contact electrodes on said distal end of said body, said array having a proximal end and a distal end; and at least one location sensor proximate to said catheter distal tip; said catheter being adapted to contacting the wall of said chamber of said heart with said catheter distal tip at a plurality of contact points; and

a signal processor for acquiring electrical information and location information from each of said electrodes and location sensors, respectively, over at least one cardiac cycle while said catheter distal tip is in contact with each of said contact points; said signal processor also generating an electrical map of said heart chamber from said acquired location and electrical information.

48. The apparatus of claim 47 wherein said at least one location sensor comprises a first location sensor and a second location sensor.

49. The apparatus of claim 48 wherein at least one of said first location sensor and said second location sensor is an electromagnetic location sensor.

50. The apparatus of claim 48 wherein said first location sensor is proximate to said catheter distal tip.

51. The apparatus of claim 50 wherein said second location sensor is proximate to the proximal end of said electrode array.